ENHANCING THE PERFORMANCE OF HANDSET ANTENNAS BY MEANS OF GROUNDPLANE DESIGN

Jaume Anguera(1), Ivan Sanz(2), Alfonso Sanz(2), David Gala(2), Antonio Condes(2), Carles Puente(3), Jordi Soler(3)

(1) MobileTechnology Department. Fractus, Bundang Technopark, 150, Yatap-Dong, Bundang-Gu, Sungnam-Si, Kyunggi-Do. 463-760 Republic of Korea
Jaume.anguera@fractus.com
(2) Mobile Technology Department. Fractus, Avda.Alcalde Barnils 64-68, 08174 Barcelona – Spain
(3) Technology Department. Fractus, Avda.Alcalde Barnils 64-68, 08174 Barcelona – Spain

INTRODUCTION

Mobile devices are in a constant state of evolution given the increasing features and frequencies available worldwide. Today, global handset functionality is becoming an important consideration influencing customer purchasing habits. Industry dynamics have increased the drive for smaller and multi-functional wireless devices. Antenna technology has played a key role in influencing the end form factor of these mobile devices because without the antenna the device is not wireless. The present paper shows a conventional design for dual-band operation (GSM900-DCS1800) and how it can be improved for a quad-band design (GSM850-GSM900-DCS1800-DCS1900) through the FracPlane® technique. This technique encapsulates both basic shaping of a groundplane to a more sophisticated space-filling and/or multilevel design for further size reduction and multi-band performance enhancement [1,4].

PIFA(Planar Inverted F-Antenna) antenna is well-known as a miniaturization radiator [5]. When a short metallic strip is added to one edge of a microstrip antenna (PIFA), the resonant frequency can be reduced by a factor of two. For example, a microstrip antenna suspended on air substrate resonates at approximately 0.5λ (without considering fringe fields); however, a PIFA antenna resonates at approximately $\leq 0.25\lambda$ which is an advantage in terms of space. For a finite groundplane with comparable dimensions to λ, as is the case of mobile handset antennas, this is no longer accurate. In this case, PIFAs can be alternatively described as an asymmetrical dipole structure: one arm acting as the groundplane while the other is the PIFA antenna element itself. Depending on the dimensions of the groundplane, different results may be obtained [1,6,7]. It has been shown that when the groundplane length is approximately 0.4λ, bandwidth can be enhanced [1,7]. This represents an interesting finding for multiband mobile handset antennas covering several services such as GSM850-GSM900 [8]. Groundplane dimensions are fixed by the PCB (Printed Circuit Board) of the handset phone. This is also fixed for product marketing purposes depending on the phone model. The combination of both of these issues requires that antenna engineers directly address the dimensions of the groundplane. For short PCBs (70-90mm length), bandwidth at low frequencies (GSM for example) is quite narrow, achieving in the best cases 7-8% SWR=3. Broadband techniques can be applied, however, such as increasing antenna height or adding parasitic elements. Both of which are prohibitive, as mobile phones tend to be very thin allowing little space for the antenna. In this sense, this paper shows how to handle the PCB in order to obtain not only broad bandwidth antenna at low frequencies to cover the GSM850-GSM900 spectrum but also at high frequencies DCS-PCS.

RESULTS

This section shows two multiband antenna designs: one uses a standard PCB while the other uses a FracPlane tuned PCB [1]. The purpose is to demonstrate that the tuned-PCB design is useful to obtain broadband behaviour at low frequencies. This is of special interest, given than a known limitation for handset antennas is usually the narrow-band of PIFA antennas at low bands, such as GSM850. Therefore, two PIFA concepts are designed and their behaviour compared to observe the benefits of the tuned-PCB approach.

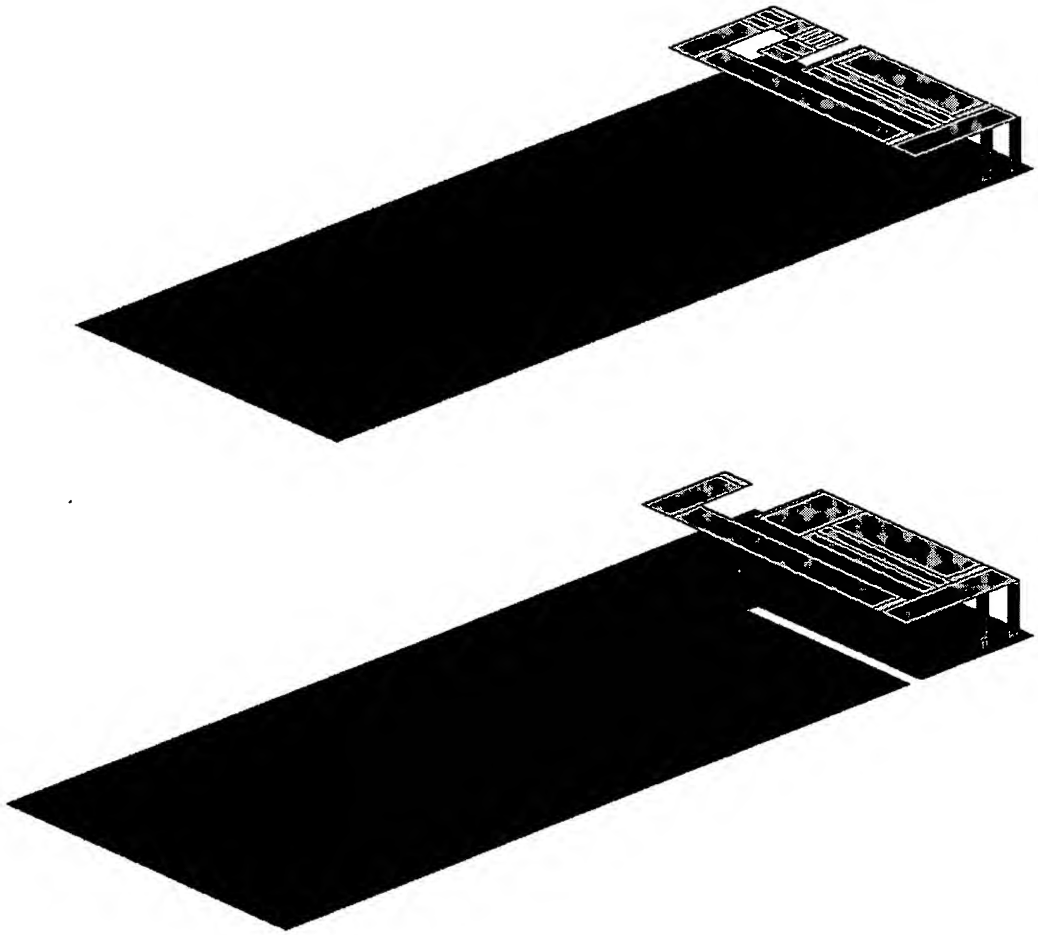

Fig. 1 Top: PIFA antenna on standard PCB 90mmx40mm. Bottom: PIFA antenna on a tuned-PCB. Antenna height in 6mm for both cases

Fig.1 illustrates two PIFA designs: one is above a standard PCB while the other is on a tuned-PCB. The tuned-PCB features a notch on the ground layer under the antenna area to limit coupling with other handset-components such as the radio-module, base-band module, SIM card, etc., requiring a ground layer.

As mentioned in previous literature [7], handset antennas may be interpreted as part of a dipole radiating structure, i.e., the PCB is considered as one arm of the dipole while the PIFA itself is the other arm. Therefore, to design high-performance antennas, one may not only focus on the PIFA design, but also on the PCB. In this sense, the PCB may be shaped to force a fundamental mode of the groundplane to resonate at a desired frequency. In the present case, the PCB is tuned to resonate at GSM900. As the PCB is a wide-metallic structure (40mm wide), it is expected to obtain a broad bandwidth when the PCB operates at this GSM frequency. As it is shown in the return losses results, if the PCB is not tuned, one can design a PIFA to resonate at GSM900 but less bandwidth is obtained given the length of the PCB. The present case uses a PCB 90mm long which is a conventional size of a bar-type mobile phone. The resonant frequency of the fundamental mode for this PCB is 1.1GHz which can be roughly calculated using the back scattering produced when a plane wave perpendicularly impinges the PCB (polarized field aligned in the direction of the PCB length).

The method to tune the PCB uses a slot as shown in Fig.1. The slot forces a longer electrical path; therefore the resonant frequency of the fundamental mode of the PCB can be decreased. This technique is similar as shown in [9].
IE3D v.10 MoM-based commercial code is used to simulate the structures. To emulate a real environment, the PCB is simulated above a thin layer of FR4 (fiberglass substrate) which is the common substrate used in most of the

commercial mobile phones. PIFA antenna design is composed of two radiating parts to obtain a dual-band performance: GSM and DCS. The slot used to tune the PCB has been designed according to the following objectives:

a) tune the PCB to resonate at GSM900 and obtain a broadband behaviour
b) couple the FracPlane design to the PIFA structure to increase its bandwidth at DCS. Thus forcing it to act as a parasitic element which improves the bandwidth at said frequency.

To see how FracPlane reduces the resonant frequency of the PCB fundamental mode, current distribution on the PCB is computed at 920MHz (Fig.2). For the standard PCB, electrical current flows from, approximately, the far-edge to the feeding area. However, for the tuned-PCB, the slot forces a longer path, thus decreasing the resonant frequency of the PCB.

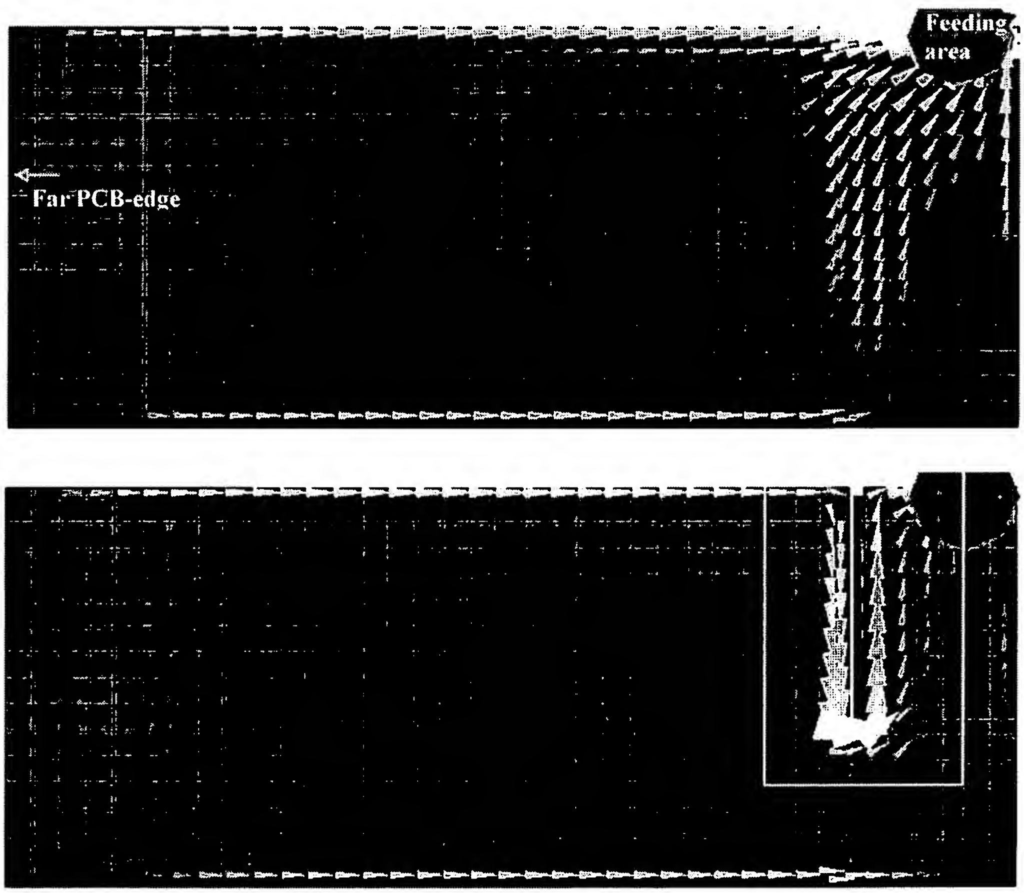

Fig. 2 Computed current distribution on the PCB at 920MHz. Top: standard PCB; bottom: tuned PCB

Figure 3 shows the antenna results for the standard and tuned-PCB after optimisation. It is clear how the bandwidth has been enhanced, not only at GSM900, but also at DCS obtaining a quadband antenna, GSM850(824-890MHz)-GSM900(880-960MHz), DCS1800(1710-1880MHz)-DCS1900(1850-1990MHz).

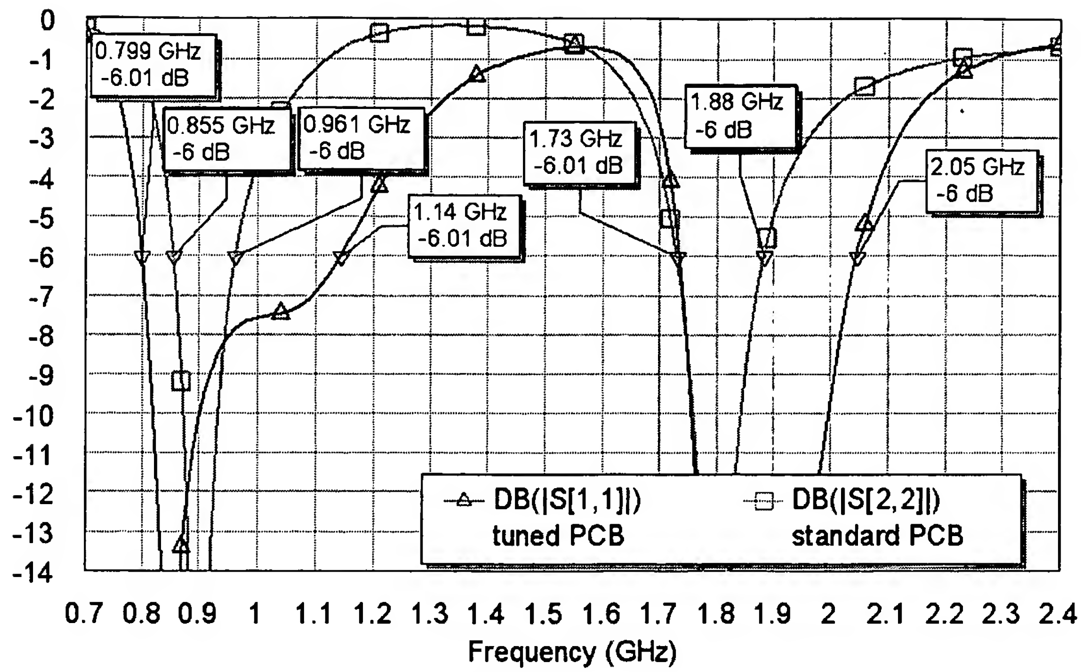

Fig. 3 Return losses for standard and tuned PCB designs

CONCLUSIONS

The PCB plays a significant role in mobile handset product design. To improve bandwidth at low frequencies, FracPlane permits tuning the fundamental mode of the PCB. This results in increasing the bandwidth of a PIFA antenna while using a standard PCB. In addition, the slot on the PCB may be used as a radiator for the highest band. This paper shows how the slot contributes to radiation, thus enhancing the bandwidth at DCS. Based on these results, the proposed design enables improved functionality for quad-band phones.

ACKNOWLEDGEMENT

This work has been financed by Fractus. FracPlane® is a registered trademark.

REFERENCES

[1] Multilevel and space-filling ground-planes for miniature and multiband antennas, Patent WO03023900, September 2001

[2] Multilevel antennas, patent WO0122528, September 1999

[3] Space-filling miniature antennas, patent WO0154225, January 2000

[4] J. Anguera, "Fractal and Broadband Techniques on Miniature, Multifrequency, and High-Directivity Microstrip Patch Antennas", Ph.D Dissertation at Universitat Politècnica de Catalunya, Barcelona – Spain 2003.

[5] T.Taga and K.Tsunekawa "Performance Analysis of a Built-in Planar Inverted-F Antenna for 800MHz Band Portable Radio Units", IEEE Trans. Selected Areas in Communication, vol.SAC-5, n°5, pp.921-929, June 1987

[6] T.Y.Wu and K.L. Wong, "On the impedance bandwidth of a planar inverted-F antenna for mobile handsets", Microwave Opt. Tech. Lett. Vol.32, pp.249-251, Feb.20, 2002

[7] P. Vainikainen, J. Ollikainen, O. Kivekäs, and I. Kelander, "Resonator-based analysis of the combination of mobile handset antenna and chassis," IEEE Transactions on Antennas and Propagation, Vol. 50, No. 10, October 2002, pp. 1433-1444.

[8] R. Hossa, A. Byndas, and M. E. Bialkowski, "Improvement of Compact Terminal Antenna Performance by Incorporating Open-End Slots in Ground Plane", IEEE Microwave and Wireless Component Lett. Vol14, n°6, June 2004

[9] J.Anguera, L.Boada, C.Puente, C.Borja, J.Soler, "Stacked H-Shaped Microstrip Patch Antenna", IEEE Transactions on Antennas and Prop. Vol.52, n°4, pp.983-993, April 2004.